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AMPLIFIER DRIFT TESTER

by Guss E. Wenzel and David Cree

Manned Spacecraft Center
Houston, Texas

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ABSTRACT

An automatic method has been developed for measuring gain drift and zero drift in dc amplifiers. Use of the method permits continuous measurement of drift with time and with a changing environment. This measurement has facilitated design of flight-stable dc amplifiers.

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SUMMARY

A method has been developed which allows automatic measurement of the gain and zero drift characteristics of a dc amplifier during long-term dynamic environmental conditions. A device employing this method compares a source signal, across a voltage divider, with an amplifier output signal. As the signal source is switched between some finite value and zero, the differential voltage between the source and the amplifier output gives an accurate indication of the amplifier gain drift and zero drift. A permanent record of this differential voltage may be obtained on a strip recorder. Measurements of gain and zero drift will be recorded automatically if the signal source is switched repetitiously, as by a motor-driven cam. Four recordings per minute are sufficient to measure drift at temperature gradients as high as 20° F per minute. This information has aided the design of flight-stable dc amplifiers. A patent has been applied for in behalf of the United States Government.

INTRODUCTION

The testing of dc amplifiers should include a procedure to determine changes in performance within the anticipated temperature range and possibly changes caused by long-term drift. A widely accepted method is to make measurements at some specified time or temperature. For example, in a long-term drift test, measurements may be made once or twice daily during a normal 40-hour workweek. Or, in a temperature drift test, measurements are usually made at ambient temperatures and at the two temperature extremes after a stabilization time. The usual stabilization time is from 30 minutes to 1 hour. If the performance is satisfactory at the times of measurement, it is assumed to be continuously satisfactory.

This assumption is not necessarily true. Fluctuations in supply and bias voltages, changes in bias currents and circuit components, variations in ambient temperature, and the like contribute to drift. In particular, performance is often unpredictable during a changing temperature. Therefore, adequate test data should be obtained to insure proper performance in conditions similar to the anticipated application.

Sufficient test data could be obtained during long-term drift tests by increasing the work shift to 24 hours a day and 7 days a week, and by taking many measurements each day. However, this method of test implementation is costly and would not provide sufficient test data during a temperature transient. A logical solution to both problems is to acquire an automatic device that will operate fast enough to measure the performance at the highest anticipated temperature gradient.

PRINCIPLES OF THE AMPLIFIER DRIFT TESTER

The amplifier drift tester measures the voltage difference between the source signal and the amplifier output signal (fig. 1). The differential voltage E will be equal to zero for all signal source voltages within the linear range of amplifier operation (constant gain equal to G), if the voltage divider (S and R) is selected to supply an input signal equal to the reciprocal of the gain G. During a temperature test or long-term drift test, with V equal to a finite value, a voltage generated at E will be a function of a zero drift and/or a gain drift. With V equal to zero, a voltage generated at E will be a function of zero drift only. If V is switched between zero and a finite value, the gain drift can be mathematically separated from the zero drift.

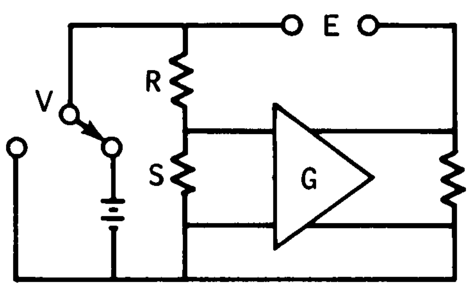
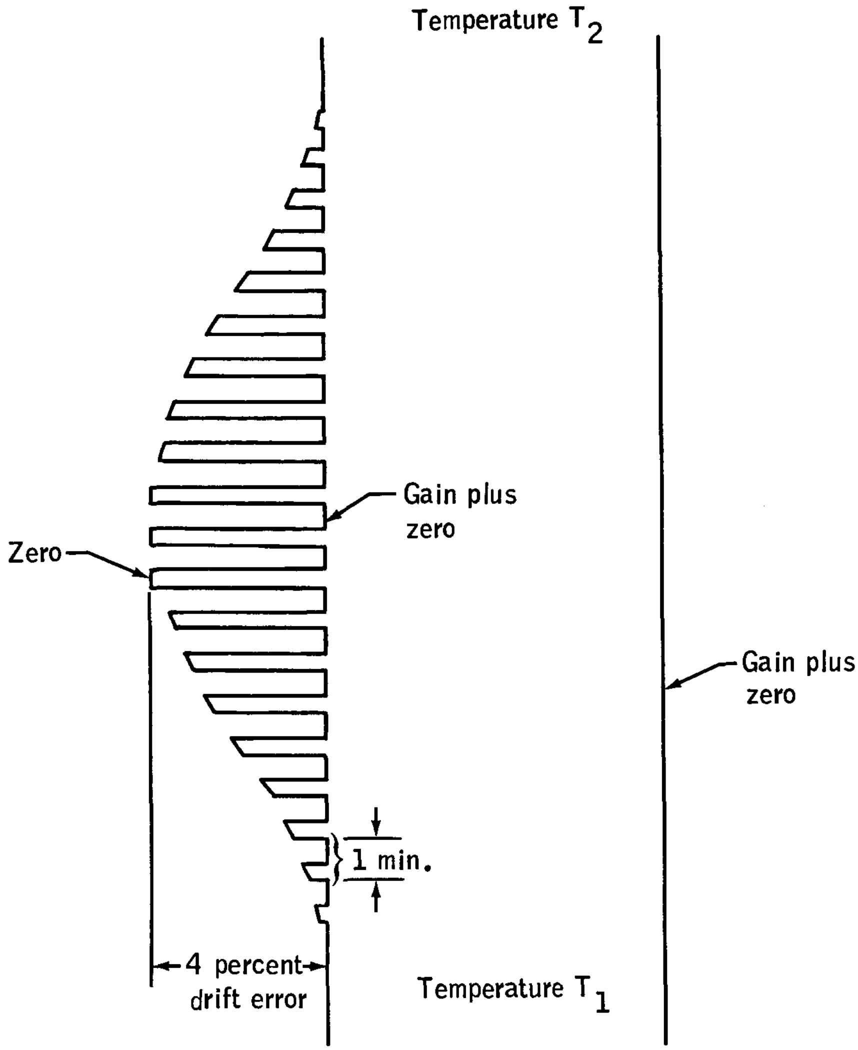


Figure 1.- Simplified circuit diagram of the amplifier drift tester.

Sufficient test data must be obtained from an amplifier to predict its operation in actual use. For example, assume that the zero and gain parameters of an amplifier are temperature-compensated perfectly at temperatures T_1 and T_2 after sufficient stabilization time. In addition, assume that the mechanical layout is such that compensation is not exactly matched to the temperature gradient, and the zero drift is exactly equal and opposite to the gain drift. Figure 2(a) represents the recorder trace when this amplifier is tested by the circuit of figure 1. The trace takes 21 minutes for complete stabilization. During this time, an error in zero setting and gain reaches a maximum of 4 percent. Figure 2(b) represents the recorder trace of this same amplifier when tested by the conventional method of monitoring the output while applying a constant input signal. Since the zero drift and gain drift are exactly equal and opposite in this example, the straight-line recording is an erroneous indication of the amplifier stability. This example is not realistic because it would be highly unusual for the zero and gain drifts to exactly cancel. This condition was selected as an example because it shows that a serious drift could go undetected in conventional testing. The important point is that an amplifier must be designed to withstand a maximum gradient as well as static extremes. Both the extremes and the gradient must be considered in testing the device.



(a) Amplifier test by circuit of figure 1.

(b) Amplifier test by conventional method.

Figure 2. - Recorder tracings of amplifier tests by circuit in figure 1 and by conventional method.

A SPECIFIC CIRCUIT

Because an eight-channel strip-chart recorder was available, a device was designed to test eight signal-conditioning amplifiers simultaneously. In addition to the zero and gain measurements, this device measures the transducer power supply voltage and checks the recorder zero setting. Figure 3 shows a typical circuit.

The 4-position switch is driven by a 1-rpm motor. Position 1 shorts the input terminals and verifies that the recorder zero has not drifted. The dwell time at this

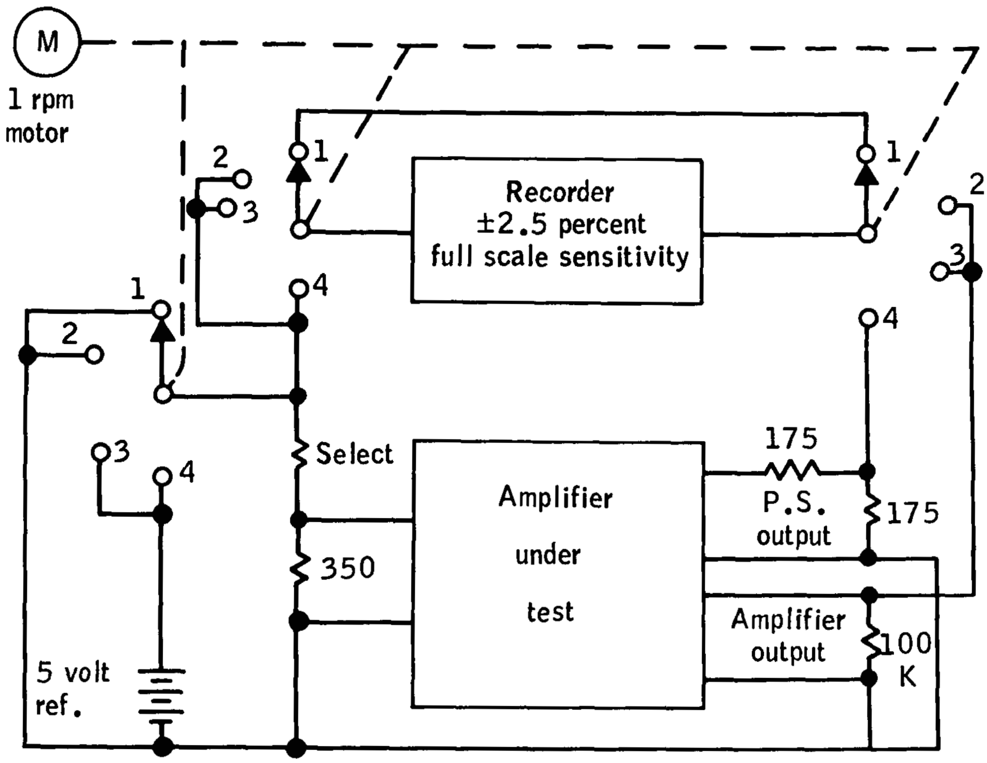


Figure 3.- Typical circuit for testing dc amplifier and transducer power supply drift versus time or environmental gradient or both.

position is different from the dwell time at the remaining positions for recorder trace identification. In the remaining positions, one side of the recorder is connected to the high side of the amplifier input signal attenuator. The recorder, being set at midscale for use as a null meter, is adjusted to read ±125 mV full scale. Thus, for a 5-volt signal at the amplifier output, the recorder will be calibrated to read ±2-1/2 percent full scale. In position 2, zero voltage is applied to the input signal attenuator, and the amplifier output is connected to the second input terminal of the recorder. Any movement of the trace position indicates a drift in the amplifier zero setting and may be read directly from the chart on the basis of ±125 mV full scale. In position 3, 5 volts are applied to the input signal attenuator. Since this signal is attenuated by the same factor as the amplifier gain, the amplifier output signal will be 5 volts. The second input terminal of the recorder is again connected to the amplifier output. Any movement of the trace position indicates a drift in the amplifier gain and/or amplifier zero setting. This movement may be read directly from the chart on the basis of ±125 mV or ±2-1/2 percent full scale. The algebraic difference between the drifts recorded in positions 3 and 2 will be the amount of gain drift. In position 4, 5 volts are applied to the input signal attenuator. The transducer bridge power supply has a nominal output of 10 volts. The center tap of a loading resistor is connected to the second input terminal of the recorder. The recorder will now read only one-half of the power supply voltage drift. Therefore, the chart calibration is changed to ±250 mV or ±5 percent full scale for this position.

In this way, four measurements are made on each flight amplifier every minute of the test. In practice, this has been found to be satisfactory for a temperature gradient as steep as 20° F per minute.

CONCLUDING REMARKS

The specific circuit described here has been in use by the Instrumentation and Electronic Systems Division, Manned Spacecraft Center, Houston, Texas, for about 2 years. Performance has been satisfactory and has aided the design and development of flight-stable, signal-conditioning amplifiers. A patent search indicates that the method is new. A patent has been applied for (NASA Case No. 5562) in behalf of the United States Government.

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National Aeronautics and Space Administration
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